DISSERTATION

FOR THE AWARD OF DEGREE

MASTER OF SCIENCE

SESSION 2022-2024

SEX DETERMINATION BY THE MEASUREMENT OF THE FORAMEN MAGNUM DIMENSIONS IN 3D COMPUTED TOMOGRAPHY

By

YASHIKA SHARMA

ENROLLMENT NO. 950122480

MASTER OF SCIENCE

IN

MEDICAL IMAGING TECHNOLOGY

DEPARTMENT OF RADIO-DIAGNOSIS

SANTOSH DEEMED TO BE UNIVERSITY

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Wish her all the success in her life.

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ABBREVIATIONS

Sr. No.	Abbreviation	Full form
1.	FM	Foramen Magnum
2.	CT	Computed Tomography
3.	APD	Anterior Posterior Diameter
4.	TD	Transverse Diameter
5.	FMC	Foramen Magnum and the Clivus
6.	ROI	Review of Literature
7.	ALOC	Axial Length of the Occipital Condyle
8.	NCCT	Non-Contrast Computed Tomography
9.	%	Percentage
10.	3D	Three Dimensional
11.	ANOVA	Analysis of Variance

ABSTRACT

Introduction: The foramen magnum is an important landmark in the posterior part of the cranial base, it is the gatway between the cranial cavity and the vertebral canal. It contains the lower end of the medulla oblongata, meninges, vertebral arteries and spinal accessory nerve; the apical ligament of the dens and the tectorial membrane pass through it to attach to the internal surface of the basiocciput. Anteriorly, the margin of the foramen magnum is slightly overlapped by the occipital condyles which project down to articulate with the superior articular facets on the lateral masses of the atlas.

Aim: Sex determination by the measurement of the Foramen Magnum dimensions in 3D Computed Tomography.

Materials and Method: The CT images will be collected from department of Radiology, Santosh Medical Hospital, Ghaziabad. In this study the foramen magnum will be measured anteroposterior diameter (APD) and transverse diameter (TD) in cms by using foramen magnum index in 3d ct images.

Results: Difference in the CT images of male and female Foramen magnum were calculated and was found that the dimensions were significantly higher in males compared to females($p<0.000$).

Conclusion: The present study indicates significant sexual dimorphism exist in these parameters. These parameters should be taken into consideration during craniovertebral and cervical spine surgicalprocedures.Morphometric analysis of foramen magnum can be used as supportive findings in estimation of sex of fragmented, incomplete or damaged dry human skulls. The knowledge of morphology and morphometry of foramen magnum is important for neurosurgeons, radiologists as well as anthropologists.

Key words: Foramen magnum (FM) Anteroposterior (AP) Transverse diameter (TD).

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CHAPTER-1
INTRODUCTION

1.1 Gross Anatomy:

The foramen magnum is an important landmark in the posterior part of the cranial base, it is the gateway between the cranial cavity and the vertebral canal. It includes the lower part of the medulla oblangata, meanings, vertebral arteries and spinal accessory nerves, the apical ligament of the dens and the tectorial membrane go through it connect to the inner part of the basiocciput. The front edge of the FM is somewhat covered by the bony protrusions of the occiput which extend downward to connect with the upper joint surfaces on the side masses of the first cervical vertebra.

1.2 Embryology:

The foramen magnum (FM) is an oval-shape opening in the occipital bone bound by the basiocciput anteriorly, the occipital condyles laterally and the supraoccipuT posteriorly. The FM is like a main spot for the growth and development of the skull base. It is found below the sagittal suture on the skull base.

1.3 Clinical Significance:

The foramen magnum may be too big, too small. A small foramen magnum can cause neurological problems, and reduced circulation of cerebrospinal fluid that can cause hydrocephalus. Identifying the gender from skull structure is crucial in forensic and medical legal situations. In numerous forensic cases the skeleton is often incomplete, which adds complexity to determining gender. Figuring out the gender of skeletons that are fragmentary or broken is a key responsibility in the field of forensic medicine. Anthropometric measurements can aid in solving such problems of sex identification. The FM was selected because it’s a common feature and is less likely to undergo significant

changes in shape. Characteristics of 1-3 FM and cranial base have identifying features for sex. Many authors have reported the usefulness of the FM in 4-9 gender determination.[1]

In cases of severe injuries, only bone fragments may be present for examination, making sex estimation difficult when only a portion of the skull is available. Therefore, there is necessity to establish standards for sex estimation using various regions of the skull. The basal region of the occipital bone is likely to survive the physical insults than the other parts of skull owing to the abundant soft tissue cover, skull thickness in the region, and its relatively well-protected anatomical position. Hence, there is a higher chance of fixing this part of skull even after serious injuries, and examining the occiput bone might offer valuable insights in figure out extensively damaged remains. Therefore, the size of the foramen magnum and its area are not very trustworthy in determining the gender of an unidentified skull, and should only be considered as additional supporting evidence. The present research was planned to evaluate the sexing potential of the dimensions of foramen magnum in forensic identification by cranio metric analysis using sexual dimorphism index[2].

The hole at the bottom of the skull, known as the foramen magnum, is oval shaped wider towards the back, with its greatest diameter running from front to back. It holds the base of the medulla oblongata, the vertebral arteries, and the spinal accessory. Hence, the measurements of the FM hold significance in clinical settings as the essential structures passing through its might face compression, as seen in cases of foramen magnum herniation. A large foramen magnum usually results from chronic increased intracranial pressure or from direct effects of an expanding process within foramen magnum like syringomyelia, Arnold Chiari malformations and also seen in children with Angelman syndrome or Rubinstein – Taybe syndrome.The knowledge of diameters of the foramen magnum are needed to determine radiological malformations (Arnold Chiari's syndrome)

[1] Radhakrishna SK, Shivarama CH, Ramakrishna A, Bhagya B. Morphometric analysis of foramen magnum for sex determination in South Indian population. Journal of Health and Allied Sciences NU. 2012 Mar;2(01):20-2

[2] Kanchan T, Gupta A, Krishan K. Craniometric analysis of foramen magnum for estimation of sex. Int J Med Health Biomed Pharm Eng. 2013 Jan 1; 7:111-3.

and prior to slicing off the opening at the base of the skull or problems in the rear part of the skull or determining the gender from skulls.[3]

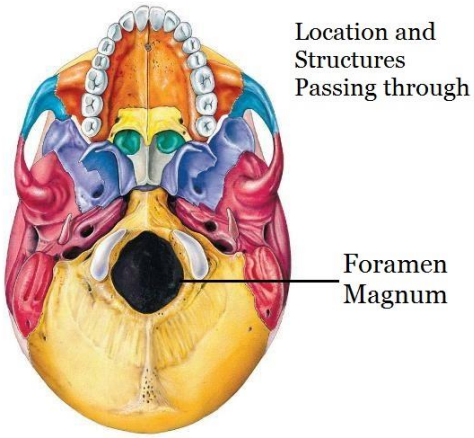


Fig.1 Foramen Magnum

1.4 Structure:

The foramen magnum, as a transition zone between the spine and the skull, plays a vital role as a landmark because of its close association tovkey structures such as the brain and the spinal cord. Different developmental changes occur at the junction where the head meets the neck, resembling deformities. A precise radiological diagnosis relies on recognizing the morphological variations and their appearance in common radiological procedures. The foramen magnum houses specific neuroanatomical structures, necessitating microsurgical interventions for their lesions. Towards the front, the border of the FM is slightly covered by the occipital condyles, which extend downwards to connect with the upper articular facets on the lateral masses of the atlas. Every occipital condyle is shaped like and oval and is situated in a way that its front part is closer to the midline than its back part. It is noticeably curved from front to back, less so from side to side, and its inner side is made rough by ligament connections. The opening for the hypoglossal nerve moves to the side and slightly forward passing beneath each condyle[4]

[3] Shepur MP, Magi M, Nanjundappa B, Havaldar PP, Gogi P, Saheb SH. Morphometric analysis of foramen magnum. Int J Anat Res. 2014;2(1):249-55.

[4] Sahoo S, Giri SK, Panda SK, Panda P, Sahu MC, Mohapatra C. Morphometric analysis of the foramen magnum and the occipital condyles. Int J Pharm Sci Rev Res. 2015;33(2):198-204.

The strong dura mater sticks to the inside of the skull bones, notably at the joints, the skull base, and surrounding the foramen magnum. Locating intact skeletons in mass tragedies can be quite a daunting endeavor and in cases criminals mutilate their victims to make their identification difficult. When bones are all smashed up,especially the skull, they can be useful for determining the individuals sex.

In literature, many authors have reported the usefulness of the FM in sex determination. There is a noticeable gap in FM sizes between the two sexes. The FM tend to have larger parameters in males which is why their heads larger than females. It's been found in studies that when they ued computed tomographic scans on living people, they discovered that all measurements of FM were greater in males compared to females.. The advantage of studying sex determination by measurements with the help of CT scan in living subjects is that sex of the living individuals is already known with 100% accuracy whereas sex of the 3D CT skull needs to be confirmed by other osteometric measurements/morphological characteristics. The FM development is regulated by various biological factors and non-biological factors during pre and postnatal period. Genes and hormonal are key factors in the realm of biological elements. The FM shows differences between males and females.

Examining the sizes of the hole at the base of the skull might be helpful in identifying the gender of an unidentified skull. The focus of this study was to evaluate the morphological differences of foramen magnum for sex determination in human individuals using computed tomography scan[5].

Moreover, the foramen magnum is clinically important because the vital structures that pass through may endure compression in cases such as: foramen magnum herniation; meningiomas and achondroplasia (Shepur *et al*., 2014). In these circumstances knowledge of the size of the foramen magnum is important for surgeons performing certain surgical procedures to reduce compression because it has clinical and radiological significance.[6]

[5] Goyal L, Srivastava PC, Agarwal S, Saxena S, Barwa J. Original Research Article Role of Foramen Magnum in Sex determination: A Computed Tomographic Study. Age (Years).;41:12-93.

[6] Moodley M, Rennie C, Lazarus L, Satyapal KS. The Morphometry and Morphology of the Foramen Magnum In Age And Sex Determination Within The South African Black Population Utilizing Computer Tomography (CT) Scans. International Journal of Morphology. 2019 Jan 1;37(1).

When the FM gets narrow, it puts pressure on the brainstem leading to issues like breathing problems, nerve issues in the head and neck, weakness in the arms and legs, and unusual muscle responses. Therefore, fundamental knowledge of this region's normal anatomy is important to clinicians when diagnosing patients. Radiological images such as those from computed tomography (CT) are widely used for FM measurements.[7]

The dimensions and form of the foramen magnum play a vital role in the progression of various disorders at the junction between the skull and the spine. So, the doctor identifying issues in this region or the surgeon conducting surgery in this area should possess fundamental knowledge if typical craniometric measurements to evaluate craniovertebral connections. When looking at communities with a diverse mix of ethnicities, the measurements of the FM decrease and become unique to that specific community. Therefore, when employed for estimation the traits and measurements of the hole at the base of the skull and the bone at the back of the head serve as valuable signs for determining gender both qualitatively and quantitatively.

In Forensic and anthropological investigations measurements of different bones are frequently utilized to estimate the age, gender, height and ethnicity of unidentified individuals. The bottom of the skull is shielded by a substantial amount of soft tissue that aids in protection of the FM. The shape and the size of the foramen magnum are crucial in the development of various disorders affecting the craniovertebral junction.. Therefore, it is vital for clinicians identifying ailments in this area and surgeons operating in this region to have a solid understanding of typical anatomy and basic craniometric measurements to assess craniovertebral connections.[8]

There are limited investigations focusing on the structure and gender based variations in the FM within the Napalese population. There was this study in Nepal where they looked at CT scans of the skull bases of 50 men nd 50 women, they measured the area of the FM

[7] Abdelaziz I, Alghamdi SS, Haroun A, Yousef M, Tajaldeen A, Aljondi R, Alghamdi S, Zidan M. Characterization of the foramen magnum in a Sudanese population using computed tomography. International Journal of Biomedicine. 2020;10(3):221-5.

[8] Vinutha SP, Suresh V, Shubha R. Discriminant function analysis of foramen magnum variables in South Indian population: a study of computerised tomographic images. Anatomy research international. 2018;2018(1):2056291.

and utilized discriminate function analysis to predict gender with 75% accuracy. This study was conducted to reevaluate the morphometry of the foramen magnum along with the occipital condyles for sexual dimorphism by using discriminant function analysis in the Nepalese population by using CT scan images.[9]

1.5 Computed Tomography:

A Computed tomographic (CT) image is a display of anatomy of a thin slice of body by acquiring and reconstructing the images from multiple X-rays absorption measurements made around the body's periphery. These CT images do not have overlapping tissues and can show much clearer contrasts because they eliminate scatter. The fundamental concept is that internal structure of an object can be reconstructed from multiple projections. The purpose of CT scanning is to take a large number of data along a thin line of two dimensional transverse section and reconstruct the structure within that slice. The first CT scanner was developed in 1972 by Godfrey Hounsfield of EMI, U.K. Since then, CT has matured greatly and gained technical sophistication. The invention of CT scanner earned Sir Godfrey Hounsfield and Alan Cormack (USA) the Noble Prize for medicine in 1979. Cormack developed the mathematics used to reconstruct the CT image. Significance of CT scans in identifying various conditions that impact the foramen magnum area. The role of CT scan in determining surgical planning and treatment for issues related to foramen magnum.

[9] Atreya A, Shrestha R, Bhandari K, Malla SK, Acharya S, Menezes RG. Morphometric analysis of the foramen magnum in sex estimation: An additional 3DCT study from Nepal on a larger sample. Health Science Reports. 2023 Jan;6(1):e999.

CHAPTER-2

AIM AND OBJECTIVES

AIM: -

Sex determination by the measurement of the Foramen Magnum dimensions in 3D Computed Tomography.

OBJECTIVES: -

- To measure the Antero-posterior and transverse diameters of foramen magnum.
- To identify the shape of foramen magnum on 3D CT images.
- To ascertain any correlation between the size of the foramen magnum in male and female skulls.
- Correlation of different shapes and Gender.

CHAPTER- 3
NEED OF STUDY

In the medical imaging field, understanding the significance of Foramen Magnum measurements through 3D CT scans is crucial for accurate diagnosis and treatment planning. To highlight how these measurements can elevate surgical precision and improve patient care. There is a lack of comprehensive studies focusing on the detailed 3D measurements of the anatomical structure. By investing Foramen Magnum dimensions using advanced 3D CT imaging technique we aim to fill this research gap and provide valuable insights for improving diagnostic accuracy and surgical outcomes in neurosurgical procedures. This study would be very useful for radiologists, surgeons and forensic experts.

CHAPTER-4

REVIEW OF LITERATURE

3.1 NihalGurlek Celik et al(2023) observed that Cranial Computed Tomography (CT) images of 130 healthy individuals (60 female, 70 male) the 18-84 age were included in our study. With the help of the 3D slicer software on those images, they discovered the anterior posterior diameter, transverse diameter, perimeter area angle between the back edge of the FM and the Clivus (FMC) value and index. The shapes of the foramen magnum were analysed. There was no statistical significance between age, FMC, and foramen magnum index values in both genders ($p>0.05$). The measurements like APD, TD, Parameters, and the area were higher in males statistically ($p<0.05$). The average FM index was 85.61 ± 6.5 for everyone, 84.94 ± 7.04 for males and 86.29 ± 5.67 for female. There was not any statistical connection between age and measurements for the whole groups ($p>0.05$). Seven shapes of foramen magnum have been seen. The most common was the oval shape (27.7%) and the least common was the pentagon (1.5%).

3.2 Paudel S et al (2023) Dimensions of the foramen magnum are clinically important because of the vital structures passing through it and for sex determination of the skull. The goal of this research was to assess different sizes of the FM in CT scans and link them to gender. They performed a descriptive cross-sectional study on 120 CT head images at the Radiology and imaging department between July and October 2019. They worked out the measurements for the APD, TD, area and index of the FM based on its shape. They ran the numbers using SPSS 25 and Excel 2016 for the statistical analysis. They employed discriminate function analysis and binary logistics regression analysis to confirm gender.

3.3 Alok Atreya et al (2022) focused in this study was to assess the morphometric measurements of the foramen magnum region and examining the accuracy of sexual diamorphism. Measurements were obtained from 3D computed tomography scan of 261 patients with known age and sex. Length and breadth of the foramen magnum ,length and breadth of right and left occipital condyles and maximum and minimum intercondylar distance were measured on the base of skull CT images.The mean values for all

parameters were higher in males than females except for the maximum intercondylar distance. Sex prediction done with discriminant function analysis could classify the skull with an overall accuracy of 70.5%–71%. Figuring out someone's gender using the morphometric study of the FM is not very dependable.

3.4 Mohammed Elfatih Elbadri et al (2022) told that this study is intended to evaluate the foramen magnum dimensions using CT scan images. The maximum front to back and transverse diameters of foramen magnum were measured, the index was calculated and the shape was identified. A total no.of 50 CT scans under this study (23 males and 27 females).The age ranges from 20 to 70 years. They saw various shapes of the FM with the most prevalent being oval, with no notable distinction (p= 2.77) between males and females. The mean width of the foramen magnum shows a significant variation between males and females, with a p value of 0.01. The FM length does not seem to differ much between males and females with a p-value of 0.069.

3.5 Nalli Prasanth Kumar et al (2020) observed that this study was conducted to investigate the reliability of four parameters of foramen magnum. They included 60 patients of CT scans of foramen magnum belonging to both gender between 20 – 50 years. The study sample comprised of 30 males and 30 females. The Circumference and the area of foramen magnum were obtained after tracing the bony margin of the foramen magnum on the CT image using CT workstation. The average values for all parameters were way higher in males than in females. When they 70% accuracy for guys and looked at how good the sex guessing was with the special maths stuff, it showed 70% accuracy for males and 80% for females giving an overall accuracy of 75%. Females were more predictable in terms of their gender compared to males.

3.6 Orhan Meral et al (2020) told that A total of 600 individuals (300 females and 300 males with an age range of 21–50 years) were studied. They put the females and the males into six age groups and did not see any major difference in the measurements between age groups for males and females (p value 0.05) the measurements of foramen magnum according to sex All measurements were significantly higher in males than in females and they provided the higher sec classification accuracy. The area of the foramen

magnum calculated b Radinsky' formula was the best measurement for sex estimation with a 75% accuracy rate. In this study conclusion is the CT images of foramen magnum show sexual dimorphism .

3.7 Haseeb Abdul Wani et al (2019) observed that NCCT head images of 378 subjects were analsed in individuals beyond the age of skeletal immaturity. Free ROI technique using electronic calliper tool was used. Mean cross-sectional area of foramen magnum in females was 806.79±106.58 mm^2 and was 878.33±98.42 mm^2

in males. Even though, males had bigger cross sectional areas than females, they did not discover any statistically significant distinction. The correlation coefficient was found to be weaker (R=0.0413). No statistically significant difference was fund between the two genders.

3.8 Samira M. Saleh et al (2019) in this study carried on 100 patients (50 males and 50 females) CT images of foramen magnum. There is significant difference between the length of foramen magnum in males and females (pv=0.00) and there is significant difference between the breadth of foramen magnum in males and females (p value=0.00) and once puberty hits, there are not much of a diff between ages. When you check out the size of the hole in the skull base, you can tell if it's a male or a female especially when other methods are not so clear you know .

3.9 Supriya Garapati et al (2018) observed in this study to assess the morphometric values of foramen magnum to evaluate sexual dimorphism. They include 100 patient (male 56, female 44) CT scans. All the CT images of foramen magnum antero posterior diameter and transverse diameter were measured. Foramen magnum index was calculated by using the formula Ht/Br X 100. The mean antero posterior diameter in males and females was 27.7 ± 2.78, 32.2 ± 2.24, the mean transverse diameter in males and females was 27.7 ± 2.27, 26.7 ± 2.68 and the area of foramen magnum in males and females was 739.5 ± 996, 676.1 ± 8.76, index o the foramen magnum in males and females was 82.09 ± 7.86, 83.02 ± 9.55 respectively. They looked at a bunch of stuff, and most of its was bigger in males than in females, except for this thing called the FM index . This was noticed higher in females than males.

3.9 Ayfer Metin Tellioglu1et al (2017) We found that men have a higher average value than women in our study. So when they did that students t-test thing, it showed a real big gap between the genders in all the stuff they measured ($p<0,05$). When multivariate discriminant function test is performed for all four measurements, the discrimination rate is 64% for all women, 70% for all men and67% for both genders.

3.10 Lucas A. S. Pires1 (2016) Morphometric analysis of crania structures are of great significance to anatomists, forensic doctors, anthropologists, and surgeons. We performed a morphometric study regarding the foramen magnum and the bony orbit on the right side of the cranium in 77 skulls with the purpose of identifying these measures on their own to figure out the gender and race of a skeleton when there is nothing else left this is because the skull can handle fire , explosions and damages. They really focus on the FM because it is in spot with lots of tough muscles and ligaments around it. They used a sliding digital caliper to take the measurements. Our results showed that the foramen magnum had a mean anteroposterior diameter of 34.23±2.54 mm, and the mean transverse diameter was 28.62±2.83 mm. The FM was mostly oval in shape. The average height of the right eye socket's height averaged at 32.89±2.45mm while the width averaged at 37.15±2.68mm.

There was a mild to moderate link between these measurements. Additionally the foramen magnum and the eye socket are crucial areas for surgery and medical care. Understanding the morphological aspects of these region is crucial as they can be affected by diseases and may need surgery for treatment.

3.11 Vishal Ramesh Jasuja et al (2016) They found that the average length of the occipital condyle was slightly larger on the left side than the right, but this variance was not considered statistically significant. In male skulls, the measurements were greater than in female skulls for both sides, and this contrast was statistically significant. The anterior inter condylar distance was found to be higher in female skulls but the difference between the genders was statistically not significant. The average antero posterior diameter of foramen magnum (ADFM)was greater in the male skulls; the difference between the genders was statistically not significant. The horizontal width was actually more in the female skulls, but the variation was not statistically important. The average

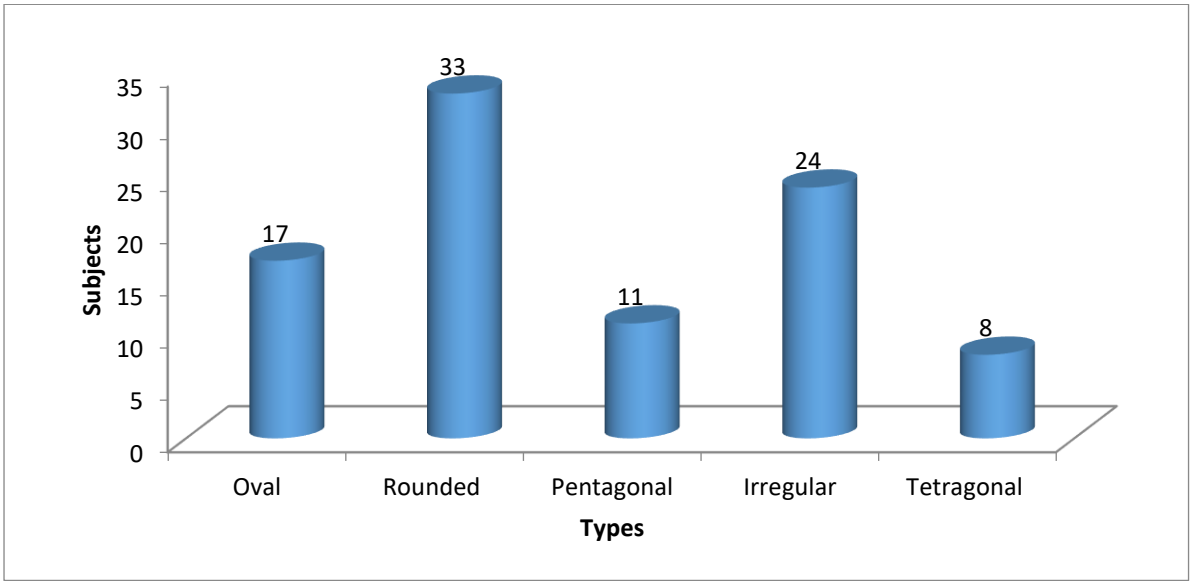
antero posterior diameter of foramen magnum (ADFM) and transverse diameter of the foramen magnum (TDFM) in the total sample was 34.13 ± 2.73mm and 27.82 ± 3.32 mm respectively. Though ADFM was greater in the male skulls (34.24 ±3.13), the difference between the genders was statistically not significant (p=0.63). As opposed to this the TDFM was found to be greater in the female skulls but the difference was statistically not significant (p=0.45).

3.12 Lokesh Goyal et al (2016) The foramen magnum (FM) is an important landmark of the base of skull and is of particular interest to many fields of medicine. In the world of literature, numerous writers have highlighted the value of the FM in identifying gender. This research aimed to examine the shape of FM to identify the sex of people using CT scans. They looked at 95 people (55 males, 40 females) aged between 20 and 70 years. They picked out the best images of FM for this study. They took note of the measurements of the FM front back and side to side diameter from the cranial CT scans and then calculated the Foramen Magnum. Information was gathered and organized using Microsoft Excel Sheet (Microsoft Office 2007). Statistical analysis was done using the statistical package for the social science (SPSS 17.0) and $p< 0.05$ was considered statistically significant. Mean age in male and female subjects was 39.98±14.26 and 42.65±10.83 years respectively. The average TD, APD and FMI were 30.25±3.14 mm and 36.20±3.19mm and 83.72±6.63mm respectively. They found a notable distinction in the mean side to side diameter (p=0.0159) and front to back diameter (p= 0.0000) between males and females subjects. There was not any significant variance in the average FM index between males and females (p=0.2418). In this research they found that there are differences between males and females in the FM. Checking out the sizes of the foramen magnum could figure out the gender of an unidentified skull statistically.

3.13 Sarthak J et al (2016) seen that in males the mean sagittal diameter is 36.7±3.12 and females the mean stand deviations is 31.8±3.03 respectively. For Males, the average TD is 33.8±2.86 and for females the average standard deviation is 27.7±2.02.

Table 1: Variable shape of foramen magnum

Types	Subjects	%
Oval	17	18.2
Rounded	33	35.4
Pentagonal	11	11.8
Irregular	24	25.8
Tetragonal	08	8



Graph1:Variable shape of foramen magnum

3.14 Kopal Saini (2015) 44 foramina magna were observed to be oval, 20 were tetragonal, 18 were round and 13 were found to be asymmetrical. The average length was 34.8 ± 2.45 (29-42) mm and average width was 30 ± 2.29 (26-36) mm. 3 skull showed occipitalization of atlas vertebra.

3.15 T.Vedanayagam et al. (2015) The total cases included were 420 and out of which 260 were male bodies and 160 female bodies. This in percentage wise constitutes 61.9 % male and 38.1% female.. The mean value of 420 cases for the sagittal diameter was 18.1 ± 0.9 mm and the transverse diameter was 25.8 ±3.2 mm. The mean value for vertical diameter of the male alone was 18.4 ± 0.7mm and the horizontal diameter was 28.2 ±

0.6mm. In female, the average value of vertical diameter was uncovered to be 17.6 ± 1. 0 mm , the horizontal diameter was 21.8 ± 0.7mm.

3.16 Venkatsssesh Gokuldas Kamath et al (2015) The sexual dimorphism of foramen magnum dimensions is established in the study. Since male and female values overlap significantly, it is not smart to only depend on the foramen measurements. Yet, given how well their sizes can predict sex in this study and previous one, the FM can aid in pinpointing the sex of the skeleton when used alongside other sexing evidence available so as to precisely ascertain the sex of the skeleton.

3.17 Rehab Ibrahim Abdel-Karim et al (2015) Sex identification using fragmented skeletal remains is a very challenging task in forensic medicine. The goal of this study was to predict sex and create a logit response model for identifying gender within the Egyptian population. They looked at CT scans of 70 adults (46 males and 24 females) who underwent temporal CT examinations in the Radiology Department. Measurements were taken for seven dimensions of both the occipital condyles and the FM. Males showed larger measurements than females.

3.18 Sanjukta Sahoo et al (2015) studied that mean front to back diameter of foramen magnum in 150 skulls was found to be 35.30 mm, ranging from 27-43 mm with a standard deviation of 2.709. The mean transverse diameter of foramen magnum in 150 skulls was 29.49 mm. ranging from 24-35 mm. with a standard deviation of 2.572.

3.19 Chandramani et al (2015) made of a morphological analysis of foramen magnum in the CT images with special emphasis on gender determination. The participants CT scans ranged from 8 to 79 years old with an even split between male and female. The mean dimensions of foramen magnum in different age group were statistically not significant ($p>0.05$).The total mean length of foramen magnum was 35.64 + 3.39 mm and mean width was 29.17 + 2.89 mm. The average size of the FM was larger in males and showed high significance ($p<0.001$). The correlations between gender and the morphology of the foramen magnum was also significant ($p<0.05$)

3.20 Anil Kumar et. al. (2015) studied the foramen magnum and concluded that foramen magnum is an important landmark in the posterior part of the cranial base, which is formed by the occipital bone. The FM size is really important in the medical field since it accommodates crucial structures passing through it. Thirty six dry human skulls of known sex, in which the front to back and transverse diameters were measured with the help of Vernier calipers. Additionally, surface area and index of foramen magnum were also calculated. Oval shape was the main type of morphological variant found in this study. In males, The FM was about 25.75-34.25mm while it was around 26-31.75mm in females. The front to back diameter was in a range of 35 to 39.75mm in males while it was 29.5 to 34.75mm in females. The average area of the FM was 876.88 ± 88.83 mm while 776.87±68.51mm in females . In contrast to the area, the mean foramen magnum index was higher in females 89.01±6.84mm compared to males 81.75±5.99mm and this difference was also statistically significant ($p<0.01$). They figured that upcoming studies will assist surgeons to set a standard to decide is the transcondylarly surgical approach is feasible. This method has been on the rise lately for treating brain stem lesions.

3.21 Roma Patel et al (2014) stated that the foramen Magnum is a large opening in the occipital bone of the cranium. In folks, the measurements of the big hole at the bottom of the skull are significant that go through it can get squished, like in cases of skull herniations , big hole meningiomas, and big hole achondroplasia. They checked out a 100 skulls, adults skulls without a known gender, and used a fancy caliper to measure how long and wide they were.. The average length of the big hole at the base of the skull was 40.2mm (range 26-40mm) and width was 28.29mm (range 21.5-33.5mm). The average hole of skull area was 755.37mm. Knowing how big the skull hole is can help doctors with radiology and neurosurgery procedures around that area. Considering above mentioned importance, this study is worthwhile.

3.22 Arthi Ganapathy et al (2014) said that the mean anteroposterior, transverse, right oblique and left oblique diameters in dry skulls and CT images were 3.39cm, 2.87cm, 2.90cm, 2.92cm and 3.49cm, 2.98cm, 3.04cm, 3.04cm respectively. The dimensions in CT images were significantly higher than dry skull and significantly higher in CT images of males compared to females. They observed that the most common shape in this study was oval, followed by irregular and the least common was round in both dry skulls and CT images.

3.23 Muralidhar et.al. (2014) reported that the mean Antero- posterior length of foramen magnum in male was 33.4mm and female was 33.1mm and by CT Imaging method in male was 38.5mm and female was 35.2mm. The average width of the big skull hole in males was 28.5mm while in females, it was 27.3mm. When checked using CT scans the width in males was 29.1 mm and in females it remained at 2.6 mm.

3.24 Gagandeep Singh (2013) Identification of human skeletal remains is the most important task for a forensic anthropologist during forensic examinations. When you have got just fragment of the skull for identification, that is when you see the necessity for techniques to figure out the gender. When they checked the measurements of the big skull hole in an Indian collection and analyzed them to see the gender differences using standard bone measuring techniques. Morph metric analysis of foramen magnum was conducted using digital vernier calipers. They ran the numbers on six standard measurements using SPSS 16 for analysis through classifier function methods. Males had higher numbers than females for all the things they measured, but only one thing (the widest part of the knee joint) showed a noticeable difference between males and females. The findings showed that there was not much difference between males and females in the base of the skull in this group. They used a certain point from the distinguishing function to decide whether a measurements was male or female above the point was male, below was female. The accuracy of predicting sex using the distinguishing function ranged from 66% to 70%. In the step by step analysis, the widest part of the knee joint was the most telling measurements with an accuracy of 60 %.

3.25 Edwards et.al. In 2013 they looked out how useful measuring the opening at the base of the skull could help tell is someone is male or female A study was performed on 250 adult individuals male144, female106 from a modern Swiss population utilizing CT data. Data was analyzed using classifier function and binary logistic regression techniques and visual observations of the morphology of the foramen magnum were made to contextualize the findings. The study found that with all variables, males and females were equally classified at 66% accuracy by distinguisher function analysis, where as binary logistic regression was comparatively poor at classifying females despite an overall classification rate of 66.4%. They checked out the base of skull in 88% of the group by just looking at it, and they categorized it into seven different shapes. However in

12% of the group could not be classified because the shape was weird caused by unevenness and complicated edges. This research figured out that although the measuring the hole at the base of the skull seem to show clear differences between males and females, it might be hard to tell the sex accurately because of how much shapes can vary. This could also affect how well we can tell someone gender just by looking at their skull, so it is not a good idea to rely solely on this method unless there are no other ways to figure it out.

3.26 Kanchan et al (2013) observed that the area of the foramen magnum was found to have better accuracy in estimation of the sex of the skulls when compared to the length and breadth of the foramen magnum. They looked that the skull metrics analysis of foramen magnum should be used only as a supportive finding in estimation of sex of fragmentary remains of skull.

3.27 S.K. Jain et al (2013) The proportions of the foramen magnum were significantly higher in men's skulls (table-2) & (table 3)

S.N. M=38	Parameter	Max	SD
1	Transverse diameter	31.5	±0.27
2	Antero posterior diameter	36.9	±0.2

Table-2 AP and TD of FM in males

S.N. F=30	Parameter	Max	SD
1	Transverse diameter	29.5	±0.28
2	Antero posterior diameter	32.9	±0.3

Table-3 AP and TD of FM in females

3.28 Radhakrishna S.K. (2012) In this study they examined the FM to investigate gender variations using typical bone measurements methods. They studied 100 skulls (55 males and 45 females) from anatomy department at Yenepoya medical college, all in good condition and with known sex information. The shape of FM on the cranial base was visually evaluated. In this research, they calculated the APD and TD and compared the gender differences ($p<0.05$) Oval shape was the most frequent followed by round square and pentagonal shapes in both sexes. The findings showed that there is sexual dimorphism in the FM. APD and TD were larger in male skulls than females (34.04 vs 31.72 and 28.63 vs 26.59). When skeletons are not fully intact, analyzing the FM metrics can offer valuable statistical insights about the gender of the unidentified skull.

3.29 AT Uthman et al (2012) FM circumference and area were the best discriminant parameters that could be used to study sexual dimorphism with an overall accuracy of 67% and 69.3%, respectively. Through the use multivariate analysis, they correctly identified the sex of males based on 90.7% of FM dimensions and females based on 773.3% of FM dimensions.

3.30 Kanodia et. al. (2012) did a comparative morpho metric analysis of foramen magnum and posterior fossa in dry skulls and using CT scan. In their study the Mean height of posterior fossa was 3.01 cm ±0.22 and 3.52 ±0.43 cm in dry skull and CT scan group, respectively. Mean volume of posterior fossa was 157.88 ±27.94 cm3 and 159.58 ±25.73 cm^3 by these methods, respectively. All the dimensions of posterior fossa and foramen magnum were larger in males as compared to females. Mean front to back (AP), transverse diameter and surface area of the foramen magnum were 3.31 ±0.35 cm, 2.76±0.31 cm, and 729.15 ±124.87 mm^2, respectively, in CT scans groups as compared to 3.41 ±0.29 cm, 2.75 ±0.25 cm, and 747.67 ±108.60 mm^2, respectively, in skull group.

3.31 Ukoha U et. Al (2011) Forensic study is very important in the identification of sex especially when the body of the deceased has been destroyed as a result of physical damage due to weapons, fire or strong chemicals. This becomes more difficult if only parts the skeletal are found or if the bones are compromised by physical insults such as

explosive or violence. The aim of this study, therefore, is to determine the presence of sexual dimorphism in the foramen magnum of Nigerian skulls, construct a distinguisher function and evaluate their practical performance in the sectioning point based on sex. The research skulls were sourced from universities in Nigeria. There were 100 Nigerian skulls in this sample, with 90 being male and 10 female. The result revealed notable differences between the sexes in the cranial base of Nigerian crania. Using sectioning point derived by the differentiator function, a value higher than the sectioning point was deemed to be male and a value below it deemed to be female.

3.32 Fatma Hayat Erdil (2010) It was found important positive correlations ($r= 0.63$; $p< 0.05$) between the transverse diameter and front to back diameter of the Foramen Magnum. There was a big gap in APD diameter among the males and females cases ($p<0.05$).

3.33 Manoel et al (2009) in this Brazilian study which showed that these were no statistically significant difference between the ethnic groups within each gender. The width of FM is larger in males 30.3 ± 0.20 than in females 29.4 ± 0.23, but not the length. They concluded that the organism linear method of the width of foramen magnum could be used to determine the morphological differences between sexes and can be used in conjunction with other anthropological techniques in gender determination of unknown individuals.

3.34 Suazo et.al.(2009) evaluated 211 human skulls from the collection of the Universidade Federal de São Paulo, They measured the forward-backward and transverse diameters of foramen magnum. Fischer linear distinctive functions. The assessment of these factors was established. Male skulls exhibited higher dimensions across the board. The size of the foramen magnum had limited ability to distinguish and correctly classify only 66.5% of the skulls. Their findings indicated that this numerical measure had restricted usefulness and should be complemented with qualitative indicators of sexual dimorphism in the occipital bone to enhance the sex diagnosis accuracy.

3.35 Khalil Awadh MURSHED (2003) In this study, aimed to assess the radiological measurements of the FM concerning gender and to identify any shape variations in the FM. In this research they checked out the CT scans of 110 healthy people, (57males and 53 females) aged between18 to 80. They used a millimeter sliding caliper to measure the FM sagittal and transverse diameters. They also estimated the FM areas. The statistical analysis for sex comparison was made using Students t test. The researchers calculated the Pearson correlation coefficient to find the relationship between the parameters studied. They also determined the frequency percentage ratios of the different shape types of the FM. The results indicated that the sagittal transverse diameter and area of FM were significantly larger in males than in females ($P < 0.001$). The statistical analysis of the correlation between all measurements parameters showed important relationships ($P < 0.01$). When it came to the foramen magnum shapes types they found it be oval shape in 8.1%, egg-shape in 6.3%, round shape in 21.8%, tetragonal shape in 12.7%, pentagonal shaped in 13.6%, hexagonal shapes in 17.2%, irregular shape(A) in 10.9% and irregular shapes (B) in 9.09%. To sum up the differences in FM dimensions between sexes and the variations in its shape carry significant diagnostic clinical and radiological implications.

CHAPTER-5
MATERIALS AND METHODS

4.1 Study Design: This is Prospective study.

4.2 Methodology: This study sample included 220 Patients data (110males and 110 females).The CT images were collected from department of Radio-diagnosis , Santosh Medical Hospital, Ghaziabad. In this study the foramen magnum were measured anteroposterior diameter (APD) and transverse diameter (TD) in cms by using foramen magnum index in 3D CT images.

APD: Anteroposterior diameter were measured in 3D CT images between basion to prosthion.

TD: Transverse diameter will be the distance between the lateral margins of the foramen magnum.

Foramen magnum index formula:

$$= \frac{\text{Transverse diameter}}{\text{Anteroposterior diameter}} \times 100$$

4.3 Inclusion criteria:

- Patients with a well-established diagnosis of normal NCCT head foramen magnum was selected for the study.
- Patients was selected from different ages (16 to 70 years), and gender .

4.4 Exclusion criteria:

- Any patient diagnosed with foramen magnum lesions, masses, or congenital anomalies was excluded from this study.
- Patient with history of trauma and surgery in the region of foramen magnum was excluded from this study.
- CT head scans of poor quality which do not clearly depict the foramen magnum was also excluded.

4.5 Instrumentations: All subjects will be examined with an advanced CT scan machine with the facility of superior image quality,. The machine used in this study is (SIEMENS CT SCANNER) which is one of the fastest 16 slice CT machines. It has a fast speed, low dose, and high-resolution images.

Fig2- MDCT Scanner (Siemens)

CHAPTER-6
RESULT

The total 220 individuals took part in this study. Out of which 50% females and 50% males. The median age of the individuals was 43years (IQR=25).The mean AP diameter of the Foramen Magnum is 33.64(SD+15.47) and the mean transverse diameter of the foramen magnum is 27.74(SD=2.33).

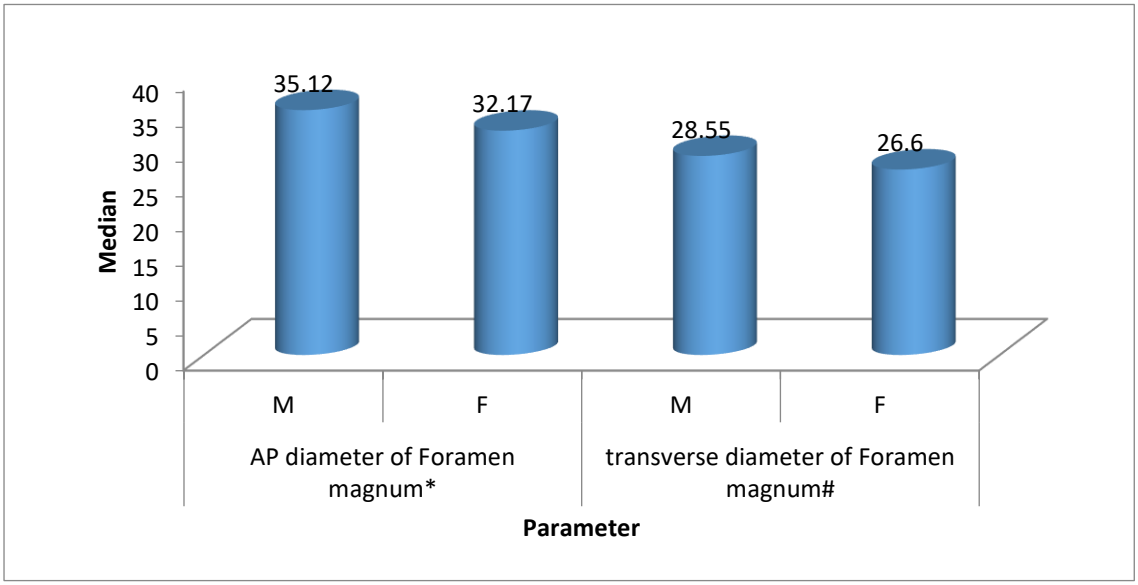
The various parameters of foramen magnum recorded in CT images are represented in table 4. The shapes of foramen magnum were visually assessed and their frequency of occurrence in CT images is represented in table 5.

Difference in the CT images of male and female Foramen magnum were calculated and was found that the dimensions were significantly higher in males compared to females($p<0.000$) as shown in table 4.

Table 4: Showing the comparison of morphometric data of foramen magnum between in CT images of males and females.

Parameter	Sex	Median (**Mean)	IQR (^SD)	p-value
Age#	M	42	22.75	0.798
	F	45	25.25	
AP diameter of Foramen magnum*	M	35.12**	2.499^	0.000
	F	32.17**	2.466^	
transverse diameter of Foramen magnum#	M	28.55	3.00	0.000
	F	26.60	3.05	

* t-test was used. # Mann-Whitney U test



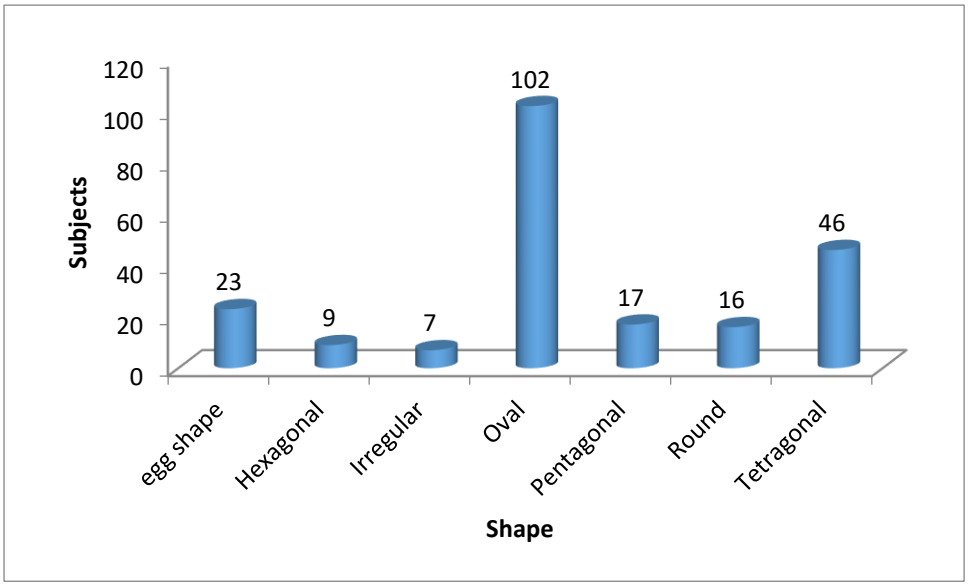
Graph 2 : Showing the comparison of morphometric data of foramen magnum between in CT images of males and females.

According to Table 4: AP diameter of the foramen magnum followed normality but age and transverse diameter of the foramen magnum did not. The mean Anteroposterior diameter was 35.12 ± 2.49 mm in males while it was 32.17 ± 2.46 mm in females. Mean length of transverse diameter of foramen magnum is 28.55 ± 3.00 mm in males while it was between 26.60 ± 3.05 mm in females and there was no statistically significant difference between the two means (p>0.000).

Table 5: Showing the percentage of occurrence of various shapes of foramen magnum in CT images.

Parameter	Category	N	%
Sex	F	110	50.0
	M	110	50.0
Shape	egg shape	23	10.5
	Hexagonal	9	4.1
	Irregular	7	3.2
	Oval	102	46.4
	Pentagonal	17	7.7
	Round	16	7.3
	Tetragonal	46	20.9

According to Table 5: The morphological types of Foramen magnum found in the present study. The incidence of these types had the following frequency of distribution: Oval 46.4%, Rounded 7.3%, Hexagonal 4.1%, Pentagonal 7.7% tetragonal 20.9 % Egg shaped 10.5% and Irregular 3.2%.

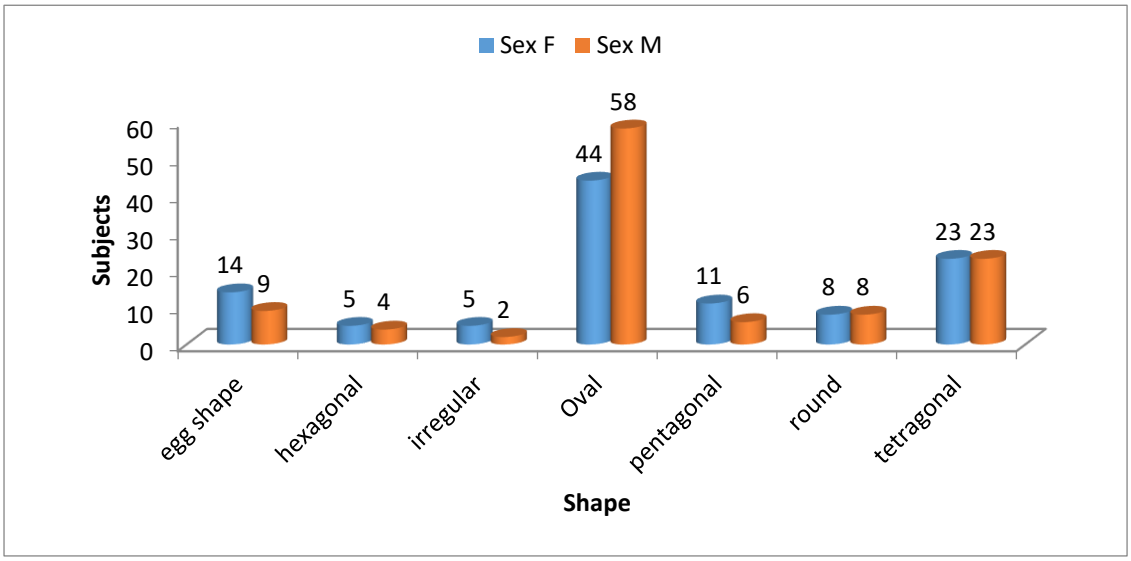


Graph 03: Showing the percentage of occurrence of various shapes of foramen magnum in CT images.

Table 6-shows There were no significant association of shapes with gender (p-value = 0.437)

Shape	Sex		p-value
	F	M	
egg shape	14	9	0.437
hexagonal	5	4	
irregular	5	2	
Oval	44	58	
pentagonal	11	6	
round	8	8	
tetragonal	23	23	

According to Table 6 : The most common shape of the foramen magnum was oval. The mean anteroposterior diameter and foramen magnum area was higher in males compared to females (p<0.000). The mean difference of transverse diameter was also more in males. One very interesting fact can be observed that all values of female are lower than males, which shows that these parameters are very important for sex determination and constitution of biological profile.



Graph 04 : Shows There were no significant association of shapes with gender.

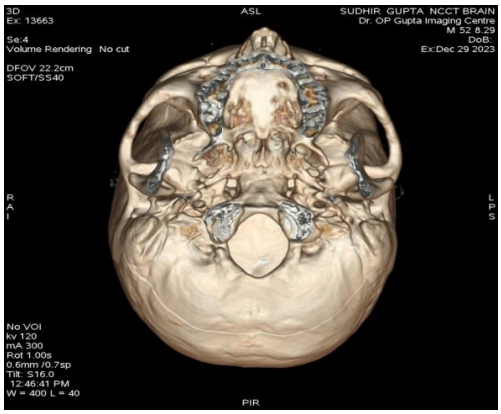


Fig.3- male egg shape of FM

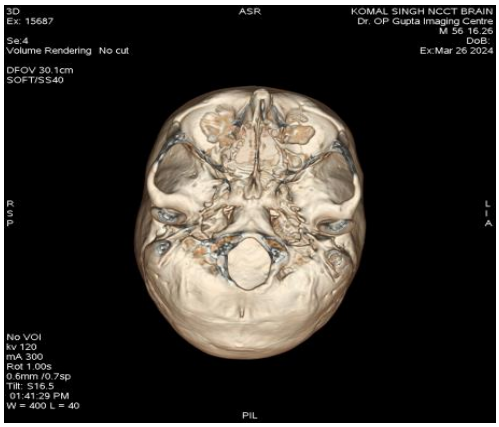


Fig.5- male hexagonal shape of FM

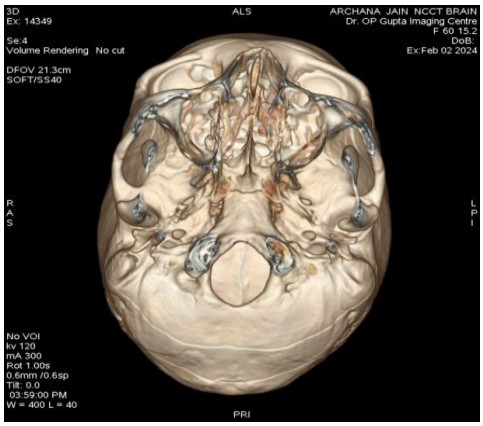


Fig.4- female egg shape of FM

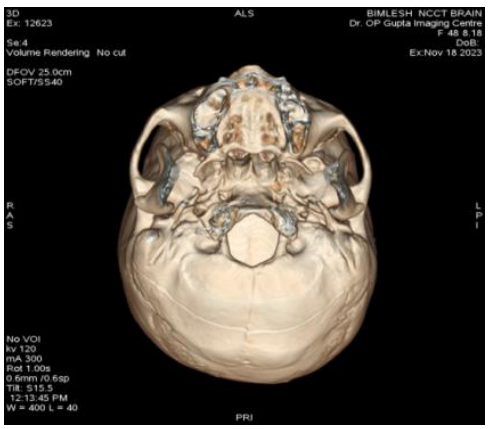


Fig.6- female hexagonal shape of FM

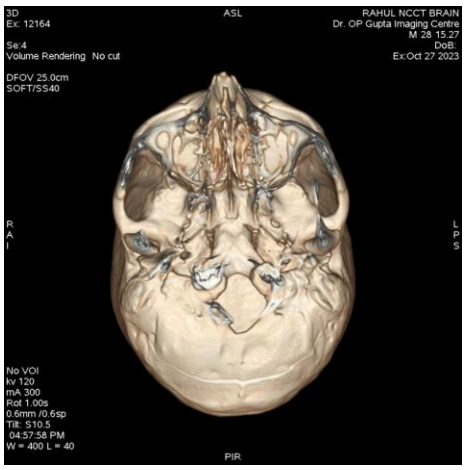


Fig.7- male irregular shape of FM

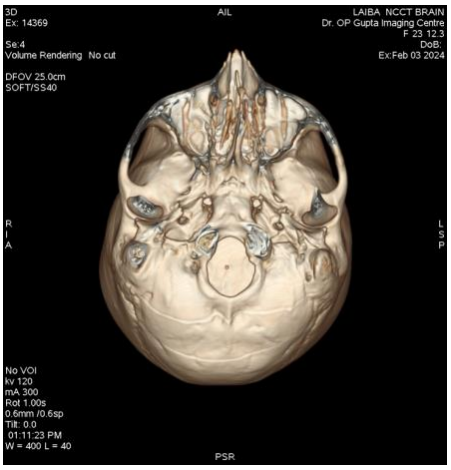


Fig.8 female irregular shape of FM

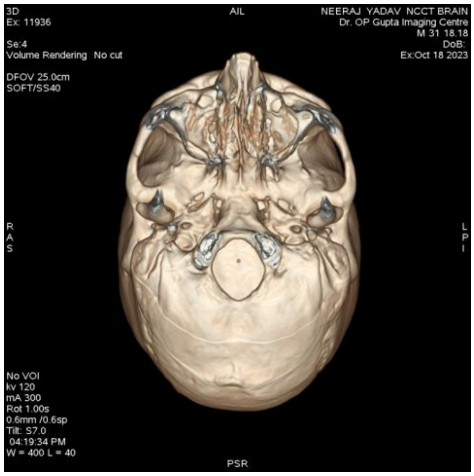


Fig.9- male oval shape of FM

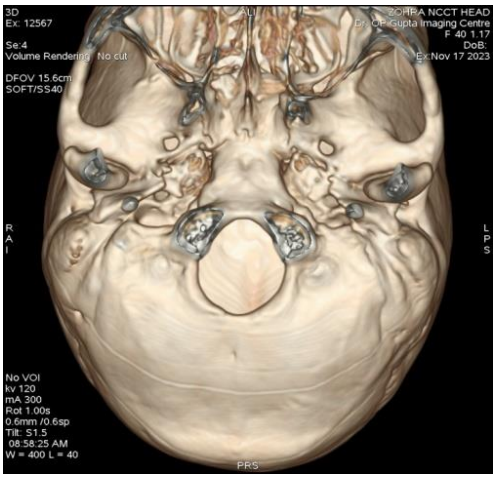


Fig.10- female oval shape of FM

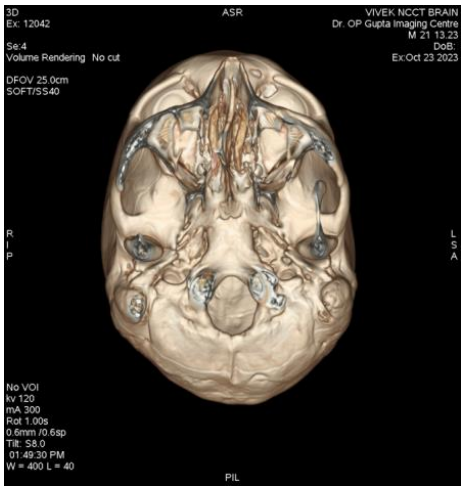


Fig.11- male pentagonal shape of FM

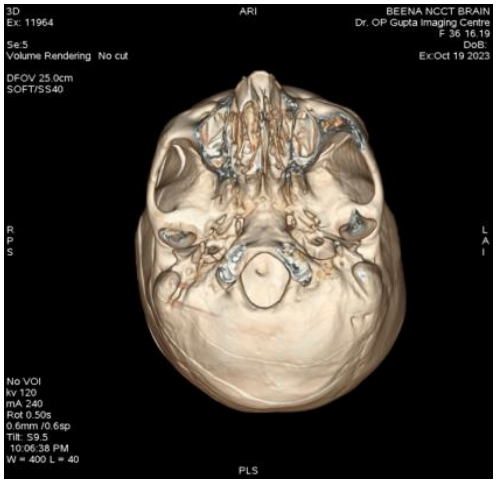


Fig.12- female pentagonal shape of FM

Fig.13- male round shape of FM

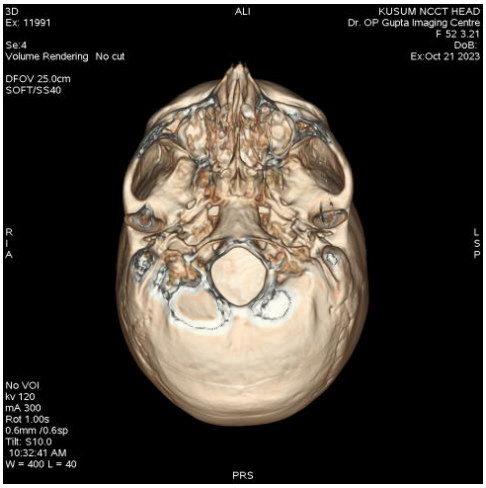


Fig.14- female round shape of FM

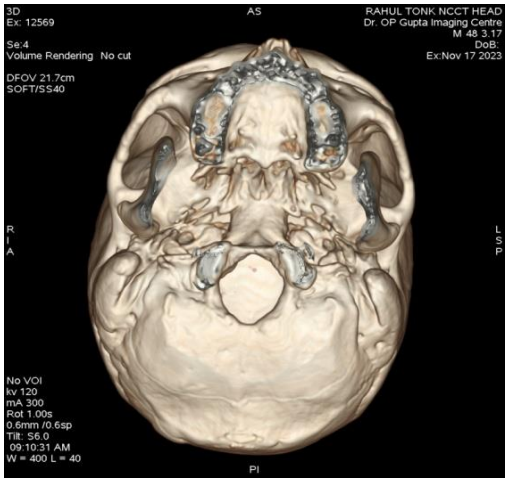


Fig.15- male tetragonal shape of FM

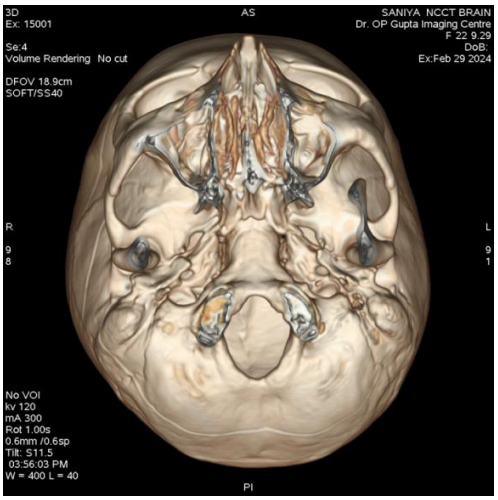


Fig.16- female tetragonal shape of FM

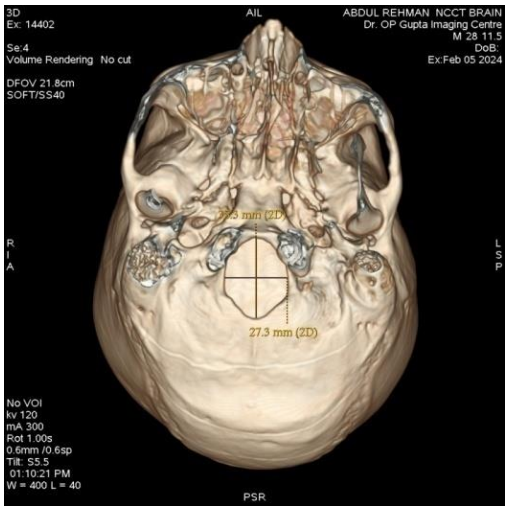


Fig.17- male AP & transverse diameter of FM

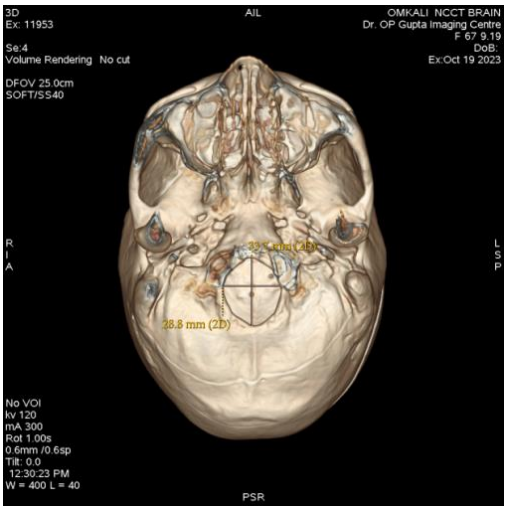


Fig.18 female AP & transverse diameter of FM

CHAPTER-7
DISCUSSION

The present study indicates significant sexual dimorphism exist in these parameters. These parameters should be taken into consideration during craniovertebral and cervical spine surgical procedures. Morphometric analysis of foramen magnum can be used as supportive findings in estimation of sex of fragmented, incomplete or damaged dry human skulls. The knowledge of morphology and morphometry of foramen magnum is important for neurosurgeons, radiologists as well as anthropologists.

It can be concluded that our results are mostly in agreement with those of other authors. Significant sex differences in the quantified parameters indicate that the

FM is larger in males. In adults, the shape of the FM is variable and remains controversial in the reports of different authors. However, it should be noted that sex differences in the dimensions of the FM and the variations in its shape should be taken into consideration during the performance of clinical and radiological diagnostics and during surgical approach.

The study confirmed that there are differences in the FM dimensions, between males and females. Yet since there is a significant overlap in values between males and females, relying solely on foramen magnum measurements may not be advisable. Despite this overlap, the high percentage of sex predictability based on their dimensions in this and previous studies suggesta that utilizing FM measurements alongside other sexing evidence can help accurately determine the sex of the skeleton.

A study on 54 skulls of Indian origin showed results similar to the present study. This reported an average APD 3.1±0.24cm and transverse diameter 2.52±0.24 cm. The various shapes of foramen magnum were also assessed by them and classified into round, egg, tetragonal, hexagonal, pentagonal and irregular shape. According to their study the most common shape observed by them was round unlike in the study where the most common shape observed was oval[30].

Literature showed two studies on CT images of healthy adults.110 healthy subjects in Turkey and showed the mean Antero- posterior diameter to be 3.46±0.31cm and trans-verse diameter 2.93±0.21cm[12]. The findings of the present study were compared with

previous studies based on different ethnic groups. 215 Brazilian skulls have shown that the mean Antero-posterior diameter was 3.52±0.33cm and the mean Transverse diameter was 3.03±0.20cm^2. Morphometric study of foramen magnum in 100 Nigerian skulls 2011 showed a mean Antero- posterior diameter of 3.62±0.23cm and a transverse diameter of 3.00±0.25cm. Another study was done on 54 subjects in Turkey showed the Antero-posterior diameter to be 3.41±0.38 and transverse diameter to be 2.98±0.27 cm[10]. They found in both studies that the measurements were greater in males than in female. These results matched what we observed in the current study. (table-7)

Table 7: Comparison of morphological types of foramen magnum and frequency of occurrence in skull with previous studies.

Types of foramen Magnum	Murshed et al [31]	Radhakrishna et al [15]	P.Chethan et al [30]	RadhikaP. M [32]	Present Study
Oval	9(8.1%)	39(39%)	8(15.1%)	60(40%)	29(58%)
Round	24(21.8%)	28(28%)	12(22.6%)	30(20%)	6(12%)
Tetragonal	14(12.7%)	19(19%)	10(18.9%)	9(6%)	-
Hexagonal	19(17.2%)	-	3(5.6%)	9(6%)	5(10%)
Eregular	22(19.9%)	-	8(15.1%)	24(16%)	-
Pentagonal	-	-	-	-	2(4%)
Diamond	-	-	-	-	8(16%)

In the CT scan images, found that the longitudinal diameter of the FM was 38.5±3.6mm in males and 35.2±3.1mm in females. The width was notably larger in males compared to females. In terms of the horizontal diameter, males measured 29.1±2.3mm while females measured 27.6±2.3mm. The average horizontal diameter did not exhibit a significant difference between male and female subjects.

[10] Çelik NG, Akman B. Anatomical analysis of foramen magnum: A 3D Slicer CT study. Medical Records. 2023;5(Supplement (1)):182-6.

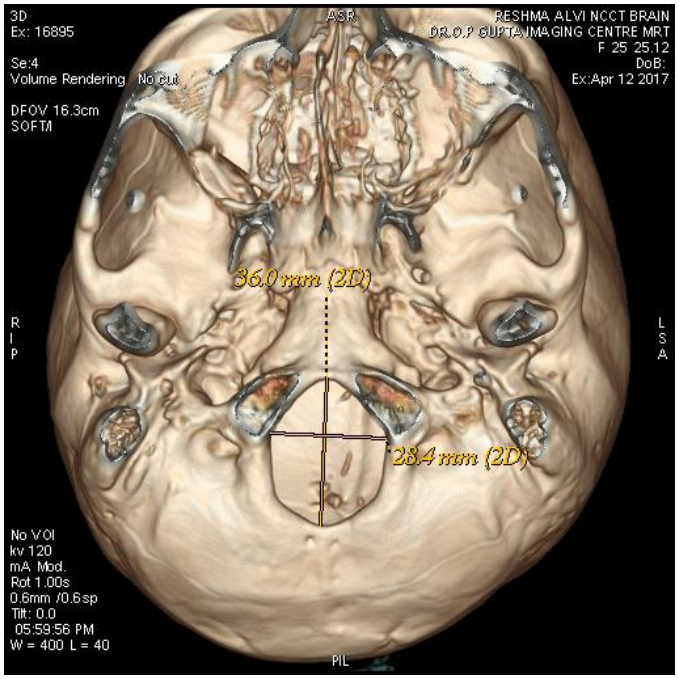


Fig.19- 3D CT image of Antero- post and transverse diameter of FM in female.

Other researchers in the field, who used CT scan to study FM diameters, also concluded that the diameters in male were higher as compared to those of females[44, 59].

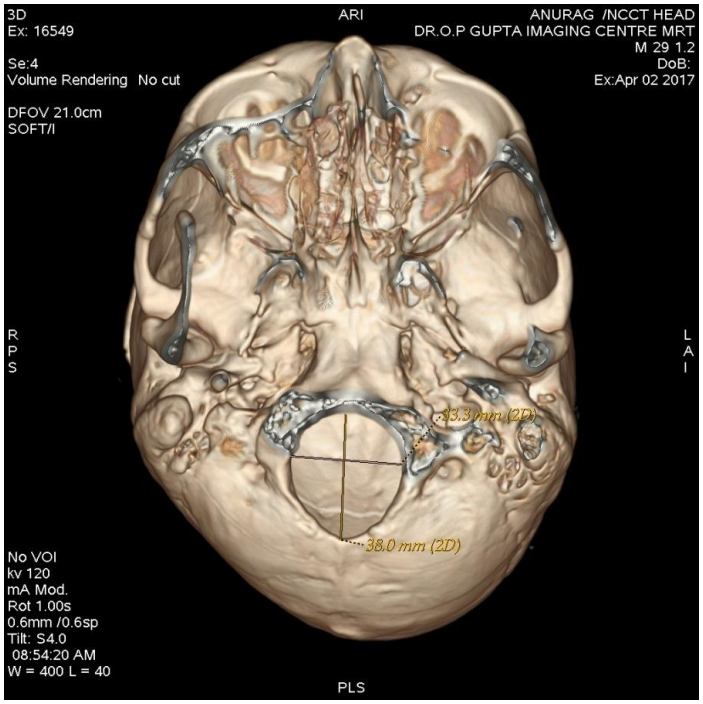


Fig.20 3D CT image of Antero- post and transverse diameter of FM in male.

FM is a regular structure at the base of the skull and is less likely to undergo major morphological changes due toit's relatively protected anatomical position, therefore it has been used for sex determination[15.]

The FM was hexagonal in 24.5%, pentagonal in 7.5%, irregular in 3.5% and round in 0.5% of the skulls.

The comparison of the quantitative analysis obtained in our study was in agreement with the results of other studies and literatures in the field. Analyzing the dimensions of the Foramen Magnum could offer valuable clues about gender of an unidentified skull, especially in the fields of anthropology and forensic medicine research.

CHAPETER-8

CONCLUSION

The accuracy of estimating skulls was found to be higher when using the FM's area rather than its length and breadth. This research in question suggests that relying on Foramen Magnum analysis for cephalo metric purposes should be seen as a supplementary approach when determining the sex of fragmented skull remains. The transverse diameter of the foramen magnum of male population is 28.64 ±2.21mm.

1. The transverse diameter of the foramen magnum of female population is 26.73 ± 2.50mm.
2. On statistical analysis the difference is found to be highly significant.
3. The Transverse diameter of the Foramen Magnum can be used to differentiate the sex with a 99.9% of confidence level.
4. The Antero- posterior diameter of the foramen magnum of male population is 34.95 ± 2.42mm.
5. The Antero- posterior diameter of the foramen magnum of female population is 32.64 ± 1.8mm.
6. On statistical analysis the difference is found to be not significant.
7. The Antero- posterior diameter of the Foramen Magnum cannot be used to differentiate the sex.

CHAPTER-9
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CHAPTER- 10

ANNEXURES

LETTER OF ETHICAL CLEARANCE FOR DISSERTATION FROM REGISTRAR OFFICE

SANTOSH
Deemed to be University
(Established u/s 3 of the UGC Act, 1956)

F. No. SU/R/2024/1344[56] Dated: 17.05.2024

Subject: Grant of Ethical Clearance for **Dissertation Protocol** Topic **"Sex Determination by the Measurement of the Foramen Magnum Dimensions in 3D Computed Tomography",** submitted by **YASHIKA SHARMA,** student of M.Sc Medical Imaging Technology, 2022 Batch.

*****

With reference to the request for grant of Ethical Clearance for the Dissertation Protocol entitled **"Sex Determination by the Measurement of the Foramen Magnum Dimensions in 3D Computed Tomography"**, **YASHIKA SHARMA** is informed that the **Dissertation Protocol** submitted by him/her was considered by the **Screening Committee** of the **Allied Health Sciences** in its meetings held on 07.02.2024 and 29.02.2024. The recommendations of the **Screening Committee** were considered in detail by the **Institutional Ethics Committee** in its meeting held on **15.05.2024** and the same was **approved** by the **Ethics Committee** of the **Santosh Deemed to be University, Ghaziabad, Delhi NCR**.

He /She is informed accordingly for further necessary action.

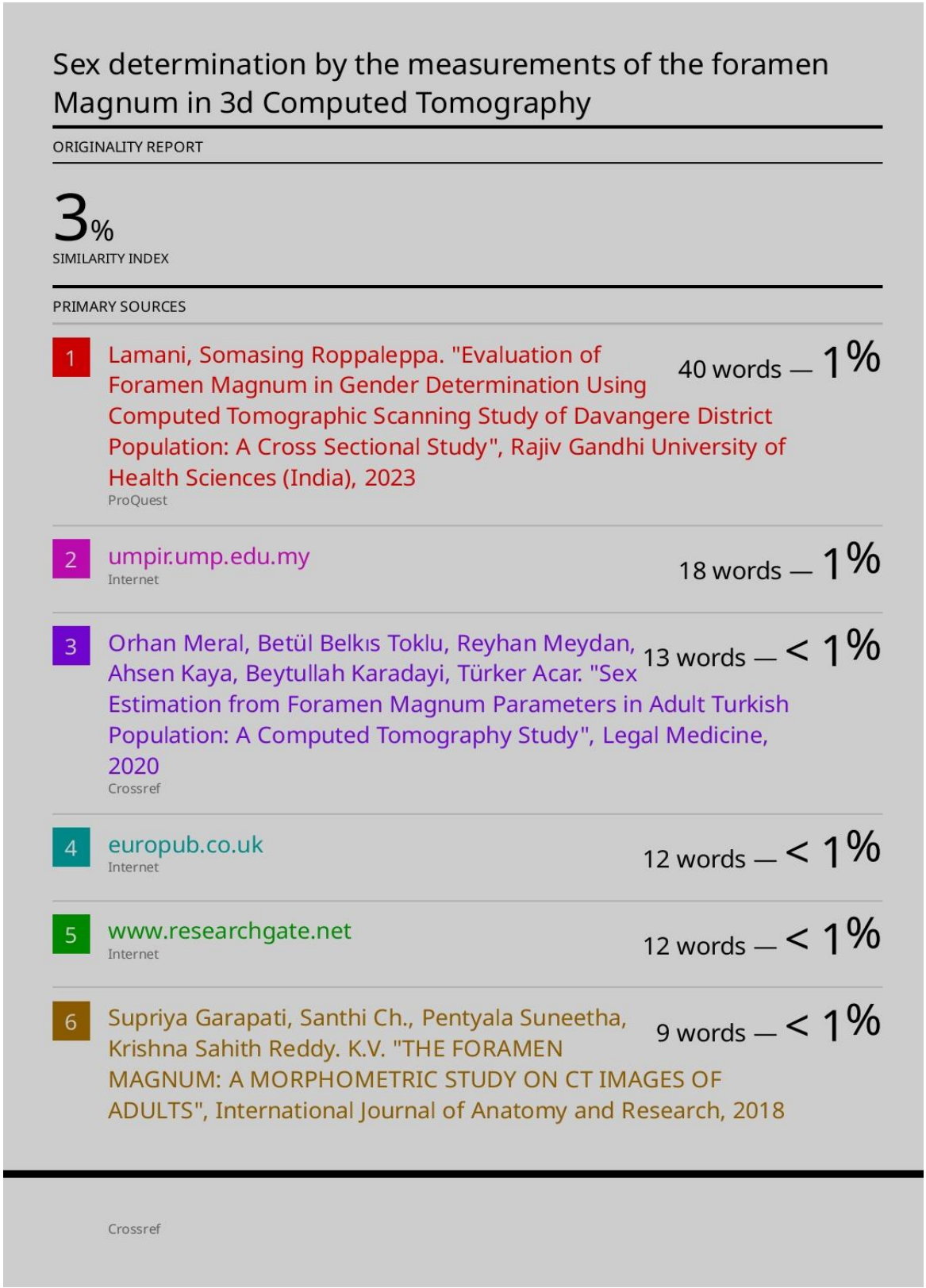
17/5/24

[Dr. EZHILRAJAN. K]
REGISTRAR

YASHIKA SHARMA
M.Sc Medical Imaging Technology.

Copy to:

1. The Vice Chancellor
2. The Dean – Academics
3. The Dean, SMC&H
4. The Dean – Research
5. The Director - IQAC
6. HOD/ Course In-charge of the concerned Department.



Sex determination by the measurements of the foramen Magnum in 3d Computed Tomography

ORIGINALITY REPORT

3%
SIMILARITY INDEX

PRIMARY SOURCES

1	Lamani, Somasing Roppaleppa. "Evaluation of Foramen Magnum in Gender Determination Using Computed Tomographic Scanning Study of Davangere District Population: A Cross Sectional Study", Rajiv Gandhi University of Health Sciences (India), 2023 ProQuest	40 words — 1%
2	umpir.ump.edu.my Internet	18 words — 1%
3	Orhan Meral, Betül Belkıs Toklu, Reyhan Meydan, Ahsen Kaya, Beytullah Karadayi, Türker Acar. "Sex Estimation from Foramen Magnum Parameters in Adult Turkish Population: A Computed Tomography Study", Legal Medicine, 2020 Crossref	13 words — < 1%
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6	Supriya Garapati, Santhi Ch., Pentyala Suneetha, Krishna Sahith Reddy. K.V. "THE FORAMEN MAGNUM: A MORPHOMETRIC STUDY ON CT IMAGES OF ADULTS", International Journal of Anatomy and Research, 2018	9 words — < 1%

Crossref

MASTER CHART

Case No.	Name	Age	Sex	Length of AP diameter of Foramen megnum	Length of transverse diameter of Foramen megnum	shape
1	**Asif**	43	M	34.8 mm	28.2mm	tetragonal
2	**Dinesh**	35	M	34.7 mm	28.6 mm	oval
3	**Mohsin**	26	M	34.4 mm	27.3 mm	tetragonal
4	**Naik singh**	55	M	34.7 mm	28.3 mm	oval
5	**Neeraj**	31	M	33.o mm	27.6 mm	oval
6	**Vinay**	50	M	34.9 mm	28.6 mm	round
7	**Bilal**	45	M	35.4 mm	27.3 mm	tetragonal
8	**Hajaruddin**	35	M	35.9 mm	31.3 mm	oval
9	**Lokendra**	46	M	38.6 mm	28.5 mm	tetragonal
10	**Mohit**	40	M	37.9 mm	30.9 mm	oval
11	**Rahul**	48	M	32.8 mm	28.2 mm	tetragonal
12	**Abdul rahman**	28	M	35.3 mm	27.3 mm	tetragonal
13	**Gopal**	52	M	30.4 mm	26.2 mm	oval
14	**Neelu**	50	m	30.8 mm	24.7 mm	oval
15	**Rajendra**	48	m	34.7 mm	30.8 mm	oval
16	**Shyam sunder**	70	m	32.6 mm	25.2 mm	egg shape
17	**Pawan**	52	m	36.2 mm	29.1 mm	oval
18	**Mohan**	38	m	32.1 mm	28.8 mm	oval
19	**Sudhir**	52	m	36.1 mm	27.8 mm	egg shape
20	**Alok**	66	m	36.4 mm	30.8 mm	oval
21	**Ayyub**	70	m	32.5 mm	24.7 mm	tetragonal
22	Bittu	40	m	36.6 mm	27.6 mm	oval
23	**Harish**	44	m	36.4 mm	27.1 mm	oval
24	**Jamalu**	50	m	33.2 mm	30.5 mm	round
25	**Manoj**	50	m	34.4 mm	27.1 mm	egg shape
26	**Moin khan**	26	m	36.6 mm	36.9 mm	round
27	**Rahul**	28	m	32.7 mm	28.3 mm	irregular
28	**Sanjeev**	40	m	37.4 mm	29.6 mm	pentagonal
29	**Subhash**	60	m	32.5 mm	30.8 mm	round
30	**Surender**	27	m	38.1 mm	27.8 mm	tetragonal
31	**Vedant**	17	m	35.6 mm	29.5 mm	pentagonal
32	**Vivek**	21	m	31.0 mm	27.1 mm	pentagonal
33	**Asif**	43	m	34.8 mm	28.2 mm	oval
34	**Dinesh**	35	m	34.7 mm	28.6 mm	round
35	**Mohsin**	26	m	34.4 mm	27.3 mm	oval
36	**Naik**	55	m	34.7 mm	28.3 mm	oval
37	**Neeraj**	31	m	33.0 mm	27.6 mm	oval
38	**Vinay**	50	m	34.9 mm	28.6 mm	oval

39	**Akshat**	18	m	33.2 mm	26.0 mm	tetragonal
40	**Ashok**	60	m	38.6 mm	31.3 mm	irregular
41	**Krishan**	48	m	33.6 mm	26.4 mm	oval
42	**P.k.jain**	50	m	39.2 mm	30.1 mm	oval
43	**Rajpal**	70	m	36.2 mm	30.5 mm	oval
44	**Rakesh**	59	m	35.9 mm	26.5 mm	egg shape
45	**Robin**	23	m	36.4 mm	32.8 mm	tetragonal
46	**Saurabh**	18	m	32.5 mm	28.8 mm	tetragonal
47	**Pawan**	45	m	32.7 mm	27.8 mm	pentagonal
48	**Hanif**	70	m	35.7 mm	30.5 mm	oval
49	**Javed**	36	m	34.4 mm	29.8 mm	oval
50	**Pramod**	55	m	40.0 mm	33.9 mm	oval
51	**Sanjay**	55	m	33.0 mm	26.3 mm	oval
52	**Anuj tyagi**	45	m	35.0 mm	31.6 mm	round
53	**Nazar**	39	m	37.8 mm	27.6 mm	oval
54	**Nitin**	22	m	33.1 mm	27.2 mm	oval
55	**Vivek**	24	m	30.1 mm	24.6 mm	oval
56	**Darvesh**	35	m	37.8 mm	32.0 mm	oval
57	**Nathan singh**	70	m	37.0 mm	28.0 mm	egg shape
58	**Piyush**	23	m	37.1 mm	33.9 mm	oval
59	**Tushar**	20	m	33.4 mm	27.6 mm	tetragonal
60	**Bilal**	37	m	34.7 mm	27.8 mm	tetragonal
61	**Deepak**	60	m	34.5 mm	28.2 mm	oval
62	**Khameedu**	50	m	35.0 mm	29.8 mm	tetragonal
63	**Mohan**	52	m	36.1 mm	28.8 mm	oval
64	**Mohd husain**	70	m	36.7 mm	27.5 mm	oval
65	**Anuj**	38	m	38.7 mm	30.9 mm	oval
66	**Krishan pal**	42	m	41.1 mm	33.7 mm	tetragonal
67	**Mohan lal**	52	m	36.9 mm	29.0 mm	oval
68	**Salman**	25	m	38.0 mm	31.2 mm	tetragonal
69	**Amit**	42	m	36.4 mm	32.7 mm	oval
70	**Ankit**	35	m	38.5 mm	27.9 mm	egg shape
71	**Babloo**	49	m	38.7 mm	28.8 mm	oval
72	**Bijender**	65	m	38.9 mm	31.3 mm	oval
73	**Deepak**	40	m	37.3 mm	31.3 mm	oval
74	**Rizwan**	40	m	36.2 mm	25.3 mm	egg shape
75	**Ajay kumar**	60	m	35.2 mm	29.1 mm	tetragonal
76	**Jitendra**	32	m	30.9 mm	28.7 mm	round
77	**Anand**	27	m	33.4 mm	24.7 mm	tetragonal
78	**Anuj**	38	m	38.8 mm	30.2 mm	oval
79	**Dev prakash**	41	m	32.0 mm	28.6 mm	oval
80	**S.k.rastogi**	50	m	35.3 mm	28.8 mm	oval
81	**Keshav**	21	m	36.3 mm	26.6 mm	oval
82	**Kiran singh**	60	m	30.7 mm	26.3 mm	oval

83	**Mohd saeed**	70	m	37.4 mm	28.5 mm	oval
84	**Prateek**	27	m	34.2 mm	28.1 mm	tetragonal
85	**Prince**	17	m	29.8 mm	24.7 mm	oval
86	**Robin**	22	m	33.4 mm	24.9 mm	tetragonal
87	**Shameem**	35	m	31.2 mm	25.9 mm	oval
88	**Shaukeen**	48	m	36.1 mm	28.3 mm	oval
89	**Vikas**	42	m	27.1 mm	34.4 mm	oval
90	**Dinesh**	40	m	32.2 mm	28.6 mm	oval
91	**Jagmal**	55	m	35.9 mm	28.4 mm	egg shape
92	**Nausad**	20	m	34.9 mm	29.9 mm	tetragonal
93	**Ram kishan**	64	m	29.9 mm	28.7 mm	round
94	**Harbir**	70	m	35.2 mm	30.3 mm	hexagonal
95	**Imran**	38	m	33.5 mm	30.4 mm	tetragonal
96	**Komal**	56	m	37.9 mm	26.2 mm	hexagonal
97	**Lakshay**	21	m	36.7 mm	31.3 mm	oval
98	**Sameer**	26	m	35.2 mm	30.3 mm	hexagonal
99	**Afzal**	33	m	35.5 mm	25.0 mm	egg shape
100	**Anil**	26	m	33.8 mm	28.7 mm	pentagonal
101	**Ayaz**	42	m	36.1 mm	26.8 mm	oval
102	**Azad**	30	m	32.5 mm	27.3 mm	tetragonal
103	**Brojose**	70	m	37.1 mm	30.9 mm	oval
104	**Dhoni**	55	m	37.2 mm	28.9 mm	hexagonal
105	**Gajender**	63	m	37.3 mm	31.8 mm	oval
106	**Gaurav**	19	m	34.9 mm	27.5 mm	oval
107	**Gurudayal**	70	m	37.5 mm	29.8 mm	oval
108	**Harish**	44	m	37.6 mm	28.3 mm	oval
109	**Babita**	48	f	32.3mm	28.0 mm	oval
110	**Beena**	36	f	28.8 mm	24.9 mm	tetragonal
111	**Khushi**	17	f	35.4 mm	28.8 mm	tetragonal
112	**Mary peter**	63	f	23.2 mm	22.0 mm	round
113	**Mehsar**	50	f	31.3 mm	24.7 mm	egg shape
114	**Omkari**	67	f	33.7 mm	28.8 mm	oval
115	**Shahnaz**	55	f	31.2 mm	25.6 mm	egg shape
116	**Bimlesh**	48	f	32.2 mm	26.4 mm	hexagonal
117	**Mahendri**	70	f	28.2 mm	28.4 mm	round
118	**Musharrat**	40	f	31.2 mm	25.5 mm	oval
119	**Shalu**	30	f	33.7 mm	25.9 mm	oval
120	**Zohra**	40	f	31.8 mm	27.6 mm	oval
121	**Archana**	60	f	33.7 mm	26.4 mm	egg shape
122	**Chandra kala**	50	f	24.4 mm	24.9 mm	round
123	**Jyoti**	30	f	38.8 mm	32.2 mm	oval
124	**Laiba**	23	f	32.7 mm	25.4 mm	irregular
125	**Muskan**	26	f	32.5 mm	30.5 mm	pentagonal
126	**Nannu**	70	f	28.8 mm	26.6 mm	oval

127	**Nellu**	50	f	30.3 mm	24.7 mm	oval
128	**Neha**	29	f	31.0 mm	25.9 mm	tetragonal
129	**Saroj**	40	f	33.7 mm	26.1 mm	oval
130	**Saroj**	70	f	33.3 mm	24.8 mm	egg shape
131	**Sheela**	60	f	25.1 mm	24.9 mm	round
132	**Suman**	45	f	34.5 mm	27.4 mm	oval
133	**Rajni**	46	f	34.8 mm	28.3 mm	oval
134	**Rajo**	55	f	30.7 mm	27.5 mm	oval
135	**Anita**	55	f	32.2 mm	25.0 mm	egg shape
136	**Ayesha**	25	f	29.3 mm	22.7 mm	tetragonal
137	**Mukesh**	48	f	31.7 mm	27.8 mm	oval
138	**Prembala**	60	f	32.4 mm	27.2 mm	oval
139	**Soniya**	24	f	29.8 mm	26.1 mm	oval
140	**Sudesh**	55	f	36.4 mm	26.6 mm	egg shape
141	**Sunita**	40	f	32.0 mm	28.3 mm	tetragonal
142	**Aashiya**	25	f	30.5 mm	26.6 mm	oval
143	**Anisha**	70	f	33.4 mm	28.3 mm	oval
144	**Anamika**	26	f	32.2 mm	28.6 mm	tetragonal
145	**Chanchal**	54	f	30.5 mm	26.1 mm	tetragonal
146	**Kamlesh**	60	f	31.0 mm	23.2 mm	egg shape
147	**Kanta**	68	f	32.7 mm	28.1 mm	oval
148	**Kusum**	52	f	30.8 mm	29.1 mm	round
149	**Mungiya**	70	f	32.5 mm	27.3 mm	tetragonal
150	**Omkali**	67	f	33.4 mm	28.8 mm	oval
151	**Pawani**	29	f	32.2 mm	30.8 mm	round
152	**Rupakshi**	29	f	35.6 mm	28.6 mm	tetragonal
153	**Sachin**	45	f	32.5 mm	26.6 mm	tetragonal
154	**Salma**	32	f	32.7 mm	28.8 mm	tetragonal
155	**sana**	18	f	32.5 mm	28.3 mm	oval
156	**Sangeeta**	55	f	30.8 mm	24.9 mm	oval
157	**Shabnam**	35	f	33.4 mm	29.1 mm	oval
158	**Suman**	40	f	29.1 mm	25.6 mm	oval
159	**Sushma**	35	f	29.8 mm	24.9 mm	oval
160	**Babita**	48	f	32.3 mm	28.0 mm	irregular
161	**Beena**	36	f	28.8 mm	24.9 mm	pentagonal
162	**Khushi**	17	f	35.4 mm	28.8 mm	tetragonal
163	**Bhavya**	28	f	31.5 mm	25.4 mm	oval
164	**Deepti**	43	f	32.7 mm	28.1 mm	round
165	**Harshi**	18	f	34.8 mm	28.7 mm	pentagonal
166	**Kajal**	36	f	32.2 mm	24.7 mm	egg shape
167	**Kusum**	45	f	29.8 mm	27.6 mm	tetragonal
168	**Nafisa**	49	f	33.0 mm	30.0 mm	round
169	**Shivani**	25	f	32.2 mm	26.4 mm	oval
170	**Siddika**	50	f	35.2 mm	30.2 mm	tetragonal

171	**Munni**	62	f	33.3 mm	29.6 mm	oval
172	**Poonam**	45	f	31.0 mm	24.4 mm	egg shape
173	**Priyanka**	43	f	32.8 mm	26.1 mm	pentagonal
174	**Balbeeri**	65	f	30.3 mm	26.6 mm	pentagonal
175	**Chaman**	60	f	31.3 mm	25.8 mm	oval
176	**Himanshi**	25	f	31.7 mm	29.1 mm	oval
177	**Manveeri**	42	f	31.5 mm	23.0 mm	egg shape
178	**Saroj bala**	65	f	33.4 mm	26.5 mm	oval
179	**Sunita**	38	f	34.7 mm	30.2 mm	hexagonal
180	**Uzma**	35	f	33.4 mm	26.9 mm	tetragonal
181	**Nirmal**	48	f	31.2 mm	23.9 mm	hexagonal
182	**Rukshar**	20	f	30.4 mm	25.3 mm	pentagonal
183	**Tasleem**	55	f	35.8 mm	25.8 mm	egg shape
184	**Sadhna**	50	f	31.0 mm	24.2 mm	pentagonal
185	**Munni**	57	f	33.0 mm	27.8 mm	oval
186	**Saniya**	22	f	31.7 mm	24.7 mm	tetragonal
187	**Zarina**	70	f	31.1 mm	25.7 mm	tetragonal
188	**Arshi**	24	f	28.9 mm	22.9 mm	oval
189	**Kalpana**	25	f	32.7 mm	26.4 mm	irregular
190	**Anjali**	30	f	34.9 mm	27.1 mm	hexagonal
191	**Khushi**	18	f	30.3 mm	25.9 mm	oval
192	**Sunita**	46	f	30.7 mm	24.9 mm	egg shape
193	**Magfura**	30	f	32.0 mm	27.1 mm	tetragonal
194	**Nazrana**	40	f	34.6 mm	26.3 mm	oval
195	**Pari**	22	f	34.4 mm	26.6 mm	oval
196	**Rakhi**	32	f	36.6 mm	25.1 mm	hexagonal
197	**Roomi**	33	f	33.0 mm	29.9 mm	pentagonal
198	**Hanifa**	50	f	35.8 mm	29.2 mm	oval
199	**Pinkesh**	48	f	30.5 mm	26.1 mm	oval
200	**Reeta**	40	f	34.1 mm	29.1 mm	tetragonal
201	**Uma**	28	f	36.6 mm	25.5 mm	egg shape
202	**Gungun**	30	f	27.8 mm	27.1 mm	irregular
203	**Hanifa**	59	f	29.9 mm	28.1 mm	oval
204	**Kranti**	70	f	31.5 mm	24.7 mm	egg shape
205	**Priya**	21	f	35.2 mm	26.4 mm	irregular
206	**Sangeeta**	30	f	30.5 mm	23.9 mm	tetragonal
207	**Sarita**	58	f	32.0 mm	27.6 mm	pentagonal
208	**Shakuntla**	70	f	32.7 mm	27.6 mm	tetragonal
209	**Uma**	46	f	36.6 mm	28.9 mm	oval
210	**Vandana**	58	f	31.7 mm	26.4 mm	pentagonal
211	**Muskan**	18	f	33.7 mm	26.9 mm	oval
212	**Poonam**	35	f	34.4 mm	25.1 mm	oval
213	**Sabila**	25	f	34.2 mm	26.4 mm	pentagonal
214	**Varsha**	25	f	31.7 mm	26.9 mm	oval

215	**Alka**	46	f	29.5 mm	23.9 mm	tetragonal
216	**Brijesh**	70	f	36.4 mm	28.6 mm	tetragonal
217	**Chander devi**	70	f	31.9 mm	26.6 mm	oval
218	**durgesh devi**	45	f	32.5 mm	24.7 mm	oval
219	**Ekta**	19	f	32.7 mm	26.1 mm	pentagonal
220	**Geeta**	27	f	33.1 mm	26.3 mm	oval